

Development of Cost Effective Smart Engine Management System for Two Wheeler Application

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ABSTRACT

The air pollution is increasing at an alarming rate now a day mainly due to emissions coming out of automotive vehicles. The exhaust emissions gases are hazardous to human health. The increased number of vehicles on road will make the scenario even worse. In order to control the pollution level, the regulatory bodies are now implementing stringent emission norms. In India, the regulatory authorities has framed the transition of BS IV to BS VI emission norms in 2020 by skipping the BS V emission norms which makes the automotive industries to work on more advanced fuel management technologies. It is more tedious to control the tail pipe emissions beyond BS IV emission norms with the conventional carburetor system since it is operating on open loop system. It is evident that in order to meet the stringent emission norms we need to have a closed loop system which controls the Air Fuel Ratio (AFR) close to stoichiometric to increase the conversion efficiency of the catalytic converter. The vehicle with fuel injection system can able to work on closed loop system, but the fuel injection system is not cost effective.

This paper illustrates the development of a cost effective smart engine management system for two wheeler application to meet the upcoming emission norms with some modification from the conventional carburetor system. Instead of controlling the fuel flow to keep the AFR close to the stoichiometric as in fuel injection system, the smart engine management system has a sophisticated air control mechanism to make the AFR close to stoichiometric. The carburetor was modified to incorporate an air control solenoid which is operated on the pulse width modulation to vary the air flow according to our requirement. The lambda sensor measures the AFR from the exhaust pipe and provides information to the ECU.

Based on the feedback from the lambda sensor, TPS, CPS, etc., the ECU maintains the AFR stoichiometric by controlling the flow through the air control solenoid with varying duty cycles. The vehicle performance test was carried out with vehicle having smart engine management system (Electronic carburetor) and also with fuel injection equipped vehicle on the chassis dynamometer. The test results show that the air fuel ratio of the electronic carburetor vehicle was maintained close to stoichiometric as in fuel injection vehicle which in turn reduce the emission to a considerable extent. Hence the smart engine management system caters a new way for an efficient low cost fuel management system.

Keywords: Engine Management System, Electronic carburetion, Fuel injection comparison, Low cost smart fuel management system, Experimental validation

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INTRODUCTION

In countries like India and China, two-wheelers are mainly used for personal transportations not as a recreational tool as used in other advanced countries. Indian two wheeler industry is aligning to current requirements and designed vehicles which are lean burn with high fuel efficiency. This is being supported by the carburetor industry to tune the carburetor for the single cylinder engine to meet the required emission norms without sacrificing the fuel efficiency and driveability.

To meet upcoming stringent emission norms without sacrificing the customer requirements such as low price, performance, high fuel economy, etc., the automobile manufacturers are now changing the conventional technology from all the parts of two wheeler. One of the most common changes is the fuel management system.

In India, the total domestic two wheeler market last fiscal, is approximately 15 million units. Most of them are running on carburetor-fed engines. The age of old carburetors are slowly getting replaced by the newer fuel injection system.

The functionality of the fuel injection system and carburetor is basically air fuel mixture management. The carburetor is a mechanical device which mixes air and fuel in a predetermined ratio by mechanical parts. On the other hand in a fuel injection system, the ratio of air to fuel that is to be mixed is determined according to the environmental and operating condition, with the help of an electronic control unit and injected at the intake system by a fuel injector [1].

The main disadvantage of the fuel injection technology is the overall cost of the system which in turn increases the cost of the final product. On the other hand, the conventional carburetor is much cheaper than the fuel injection system but they cannot meet the upcoming stringent technical requirements. Hence, this cost and technology trade off trend leads to a development of cost effective smart engine management system which will meet the stringent technical requirement as well as the lower cost requirement.

CURRENT SCENARIO

The conventional mechanical carburetor works on the principle of constant depression at the venturi region to deliver the required amount of air fuel mixture at the upstream of the engine induction system. The air fuel mixture delivered to the engine from the carburetor depends on the loading conditions. i.e., throttle opening and engine RPM. The conventional carburetor is normally tuned with rich air fuel mixture in the idling and low end throttle load to increase the stability of the engine in order to overcome the charge dilution problem. The cruising condition is tuned with leaner mixture to increase fuel economy, since the lean mixture is enough to run the engine optimally. The AFR is tuned richer again at the rated power condition to achieve maximum power [2]. Typical AFR curve for conventional carburetor at various loading conditions is depicted in Fig.1.

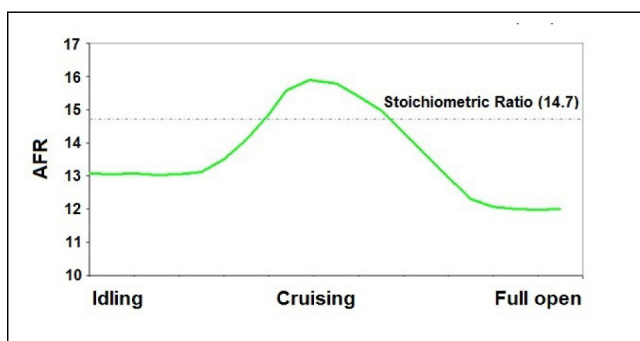


Fig.1. Typical AFR curve for conventional carburetor

The carburetor system is easy to operate, cheap to replace, quick servicing and finally at a lower cost. The main drawback of the carburetor system is the varying air fuel mixture.

FUTURE TRENDS

Nowadays, all over the world the governments are imposing stringent emission norms which push the OEM to select a fuel management system which will meet emission norms as well as customer requirements. In India, the new emission norms which are expected

by 2020 are very stringent than current emission norms. So that the existing power train system in a two wheeler will not be able to meet BS VI emission with open loop system. (without feedback).

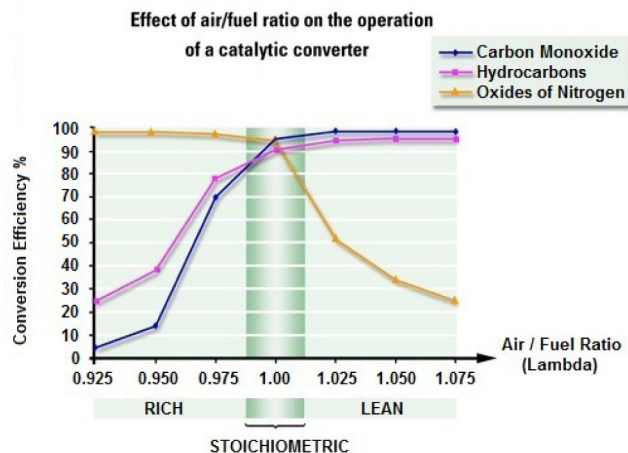


Fig.2. Conversion efficiency of catalytic converter

Future technology definitely require a closed loop control mechanism in which air fuel ratio fed to the engine can be maintained closer to stoichiometric ratio [3]. Every engine requires air fuel ratio at 14.7:1 for chemically complete combustion to take place. This also enhances the catalytic converter for its best conversion efficiency. Fig.2. shows the catalytic converter conversion efficiency for various AFR range. Maintaining the AFR to stoichiometric ratio is possible only through a closed loop control of air fuel system.

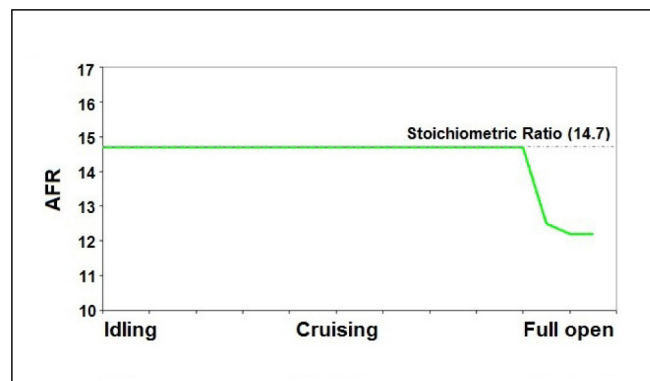


Fig.3. Upcoming AFR trend for various throttle loads

Fig.3. shows the typical AFR trend for the upcoming advanced fuel management system for various throttle load conditions. The closed loop control system to maintain the AFR close to stoichiometric can be possible by two advanced fuel management technologies i.e., Fuel injection system and Electronic carburettor system, which is described in this paper.

FUEL INJECTION SYSTEM

The fuel injection system consist a number of components which are used to control the air fuel mixture such as ECU, sensors, fuel pump, throttle body and injector. There are multiple sensors available with the fuel injection system to find the engine rpm, engine temperature,

intake air temperature, throttle position, manifold pressure and piston position. These inputs are fed into ECU to evaluate engine operating condition. Then the quantity of fuel to be injected is determined by the ECU.

The required amount of the fuel is injected into the induction system of the engine by a fuel injector. The fuel pump delivers a high pressure fuel to fuel injector prior to injection. The throttle body which replaces the carburetor is the only mechanical part in the fuel injection system. Oxygen sensor is also adapted with system to evaluate the engine AFR by measuring the oxygen content of the exhaust gas.

The measured AFR is fed into ECU to apply the correction in the amount of fuel delivery to the engine, which is necessary to maintain the AFR at stoichiometric ratio [4]. Fig.4. shows the Schematic block diagram of Fuel injection system

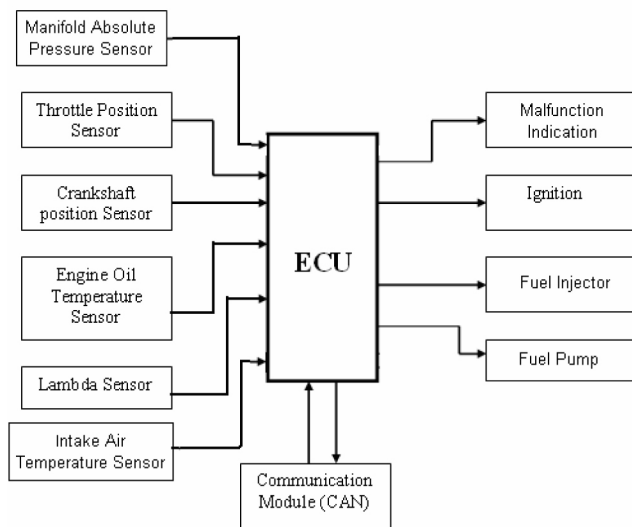


Fig.4. Schematic block diagram of Fuel injection system

ELECTRONIC CARBURETOR SYSTEM

The electronic carburetor system consists of an air control solenoid integrated into the constant depression carburetor system instead of variable depression carburetor as in earlier electronic carburetor system [5]. The electronic carburetor system also consists of electronic control unit and various sensors. Electronic carburetor delivers a proper air fuel mixture depending on operating condition such as starting, cruising, acceleration, deceleration and full load. In this electronic carburetor system, sensors, ECU is used to maintain air fuel ratio at stoichiometric by control the secondary air supply through air control solenoid. The oxygen sensor placed at exhaust pipe measures the engine AFR which is fed into ECU. Based on the feedback from the oxygen sensor, ECU controls the flow rate of air through the engine intake system with the help of air control solenoid to maintain stoichiometric air fuel ratio [6]. In electronic carburetor system, in addition to controlling of the air fuel mixture as in earlier electronic carburetor system, the ignition is also controlled based on the varying engine operating conditions to meet future technical

requirements in terms of driveability, emission performance, etc., Fig.5. shows the schematic block diagram of current electronic carburetor system.

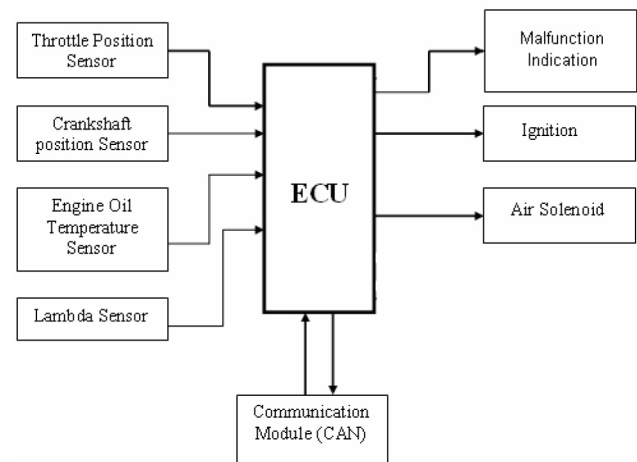


Fig.5. Schematic block diagram of Electronic carburetor System

The number of components i.e., the sensors and actuators used to control the air fuel ratio stoichiometric in both electronic carburetor and fuel injection technology is compared and listed in the Table.1.

Table 1. Comparison of components for Electronic Carburetor versus Fuel injection system

DESCRIPTION	ELECTRONIC CARBURETOR	FUEL INJECTION
Sensors	CPS	CPS
	TPS	TPS
	EOT	EOT
	Lambda Sensor	Lambda Sensor
		IAT
		MAP
Actuators	Ignition Coil	Ignition Coil
	Solenoid	Fuel Injector
		Fuel Pump
Others	Carburetor	Throttle Body
	ECU	Intake Manifold
		ECU

VEHICLE TESTING

The vehicle testing with both the fuel systems to evaluate the vehicle performance on various operating conditions such as road load test, wide open throttle test, cold startability, drive cycle, driveability test and idle sweep test. Table. 2 show the engine specification that is used for the vehicle testing.